Integrating Non-Pollutant Indexes into Pollution Levy Calculation: Theory and Implications for the Pollution Control in Tibet, China

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Abstract

Pollution levy calls for a levy on the negative externality generating activity equal to its marginal external damage. In Tibet, it is difficult to compare the levy with the marginal social cost because the environmental damage originating from various non-pollutant factors vary significantly as the implementation of the Western China Development Strategy. This study presents an expression of the optimal pollution levy for regulating the negative externality released into Tibet environment of producing a national consumed resource. The result suggests there is still a considerable room for improving the effectiveness of the pollution levy through integrating the non-pollutant indexes into the levy calculation. Policy proposals for the further development of the current levy system are made.

1. Introduction

The focus of this study is on the appropriate pollution levy in Tibet. The Chinese name for Tibet means “the western storehouse”. The area has rich deposits of natural gas, petroleum, hydro-electric power, and other important mineral resources. Reserves of gold, lithium, uranium, chromate, copper, borax and iron account for a significant share of the world’s reserves. Tibet will hopefully become one of China’s important mine bases and the exploitation of natural resources will become a main component contribute to the region’s economic growth in the future (赵, 2005, pp.78-79). However, while resources exploited, pollutants produced along with mining released into the environment may cause both local and cross border pollution damaging both nature and people (Blinker, 2002; Blaikie and Muldavin, 2004).

Pigou (1920, pp. 931-936) provided means for internalizing the social cost associated with pollution. The standard Pigouvian solution calls for “a tax per unit on the externality generating activity equal to its marginal external damage” (Baumol and Oates, 1988, p.55). Under such levy scheme, the social cost is embodied in the private cost so that the social optimum can be achieved in a competitive market. In the later work, Pigou (1928, pp. 94-99) clarified the taxation of negative externalities raises revenue to be spent on the provision of positive externalities. Pearce (1991) suggested the increased levy on pollution activities can provide two kinds of benefits. The first is an improvement in the environmental quality and the second is an improvement in economic efficiency from the use of this to reduce other levies, such as income levies that distort labor supply and savings.

In China, pollution levy system is the most important pillar of the industrial pollution regulatory system, which have been used to control social cost and provide additional revenues for environmental projects (葛, 王, 2006). The levy system was introduced in 1978. Clause 28 of the Environmental Protection Law (EPL) specifies “in cases where the discharge of pollutants exceeds the limit set by the state, a compensation fee shall be charged according to the quantities and concentration of the pollutants released". The nationwide implementation of this system began in 1982 when the Provisional Regulations for Collection of Compensation Fees for Pollutants Discharge was issued by the State Council. In 1996, the system was implemented in all counties and cities (Jang, 2004, p.9).

A series of empirical studies show the pollution levy system has played an important role in preventing China's environment from further deterioration. Using firm level data, Dasgupta et al. (1996) found changing to a full emission levy system would greatly reduce overall abatement cost. Wang and Wheeler (1996) found the water pollution levy system is neither arbitrary nor ineffective. China provincial level data on water pollution over time was analyzed and the result suggests pollution discharge intensities have been highly responsive to provincial levy variations. Using five year environmental and economic data for 28 provinces, autonomous regions and municipalities direct under central government, Jiang and McKibbin (2002) examined the effectiveness and efficiency of China's pollution levy system. The study shows China's pollution levy system is effective and works better for water pollution.

While externality provides a rationale for government intervention in competitive markets, the precise application of pollution levy is difficult in practice. The use of the levy involves decisions on how much negative externality to be internalized. In Tibet, it is difficult to compare the levy with the marginal social cost because the damage originating from various non-pollutant factors vary significantly as the implementation of the Western China Development Strategy (WCDS).

First, when China was centrally planned economy, the government administrated the price of the resources and supplied them from west to east for processing at low cost. Until the early 1990's, the policy of supplying the eastern region with raw materials from the western region at low price was still an important part of policy supporting the development of the eastern region. Prices for resources from the western region were artificially low. Since the reform and opening up of China, because many resources can be purchased from the international market, the demand of eastern region for western region lessened. But there is no change in the regional division that the western region explores and supplies resources and the eastern region processes and manufactures goods, while, prices for resources are market determined (Lin and Liu, 2004). Since the Qinghai-Tibet railway will eventually connect Tibet with the national market, exogenous price will become an unreliable indicator in the presence of the social cost incurs to the resources exploitation.

Secondly, the Chinese government is presently opening new channels for developing Tibet economy and the fundamental role of the basic facilities is increasingly apparent. In the exchange of raw materials for manufactured commodities, the great improvement of transportation facilities can greatly decrease the transport cost. Since the opening of many transports, storage and post facilities, costs of freight for raw materials out of Tibet have decreased by a large margin. In addition, the key productive elements for economic development, such as capital, labor and technology, will enter Tibet at a reasonable price. Through optimizing these kinds of key productive elements, the productivity of mining can be rationally enhanced (Zong, 2003). Therefore, sharply downward shifted marginal production cost should be considered in setting the appropriate pollution levy.

Thirdly, technologies tools are now available to counter the negative impacts of mining. There may be a considerable reduction in the damage done to natural capital. For an example, acid drainage may be treated actively. The treatment involves installing a water treatment plant, through which the acid drainage maybe neutralized. However, the costs involved in operating a treatment plant can be high and require constant maintenance (Mining, Mineral and Sustainable

Development, 2002, pp. 238-239). Tibet environmental issues have not only predominantly local impacts, but also accumulated national and international impacts. Awareness about mining and its impact on the environment has already evolved considerably by the central government authorities. Improving investments in the wastes disposal and pollution treatment projects will have big environmental payback (中国国家环境保护总局, 2006, pp. 538-540). It would clearly be in the interest of the Tibetans to get these done with public funds, since they can effectively reduce the amount of external cost of resource exploitation.

To sum up, the internalization of negative externality calls for the true marginal production and social costs to arrive at the appropriate levy. It is necessary to estimate with precision how much the polluter should pay for mining operations when their marginal costs depend very much on the basic facilities and pollutants treatment facilities installed in Tibet. Moreover, good economic policy suggests that identifiable environmental cost to be internalized on a condition of the steady price. Confusion will arise when the national market price for the resource is exogenous and easy to verify, because the price does not reflect the social cost incurs to the resource exploitation and might sign a comparative advantage encouraging excessive exploitation.

Central to this issue, in section 2, a simple economical model is built, in which non-pollutant factors are represented, to obtain the optimal pollution levy for regulating the negative externality released into Tibet environment of producing a national consumed resource. In section 3, features of the current implemented pollution levy for industrial water and air pollutants are outlined. Related to the theoretical finding, policy proposals for the further improvement of the current levy system are made. Finally, conclusions are drawn.

2. Theoretical basis

The first-best levy is to be investigated with the following assumptions. Local (Tibet) economy is assumed to trade with the rest of the country. The trade does not involve transportations across national boundary, so that no custom is imposed on the exchanged goods. The central (Chinese) government designs its regional economic and environmental projects. It lays out capital and introduces technique into the local economy in the upgrade of infrastructures and pollution treatment facilities. These are valid assumptions for Tibet in the WCDS.

Two private goods, resource X (e.g., copper) and consumption goods Y(e.g., color TV) are produced and consumed in the local economy. Let local economy have the advantage of producing X. Choose goods Y as the numeraire, the relative price denoted by p^* for X is exogenously determined by national or international markets. Exploitation of each unit of resource X generates pollution Z (e.g., acid drainage) as a by-product, so that X is the pollution sector. Assuming that per unit effluent rate ρ is fixed, the total pollution emission Z released into environment is ρX (Copeland, 1994).

There are two kinds of agents, a finite number of households and perfectly competitive firms in the economy. The assumption that the firm is a profit maximizing entity obviously is not always valid for Tibet, but it is becoming increasingly applicable. A significant portion, 70 percent, of Chinese gross domestic product is produced by private firms many of which are in price taking, competitive firms (Goulder, 2005). While the state owned enterprises managers' incomes are more and more correlated with the economic performances of the plants, it is in most plant managers' interests to maximize profits (Wang, 1999).

Households are denoted by $h = 1, \ldots, H,$ who derive welfare from the consumption of both X and Y. Household's preference can be represented by a utility function

$$u^h = u^h\left(x^h, y^h\right),$$

where x^h and y^h denote the realized consumption of X and Y, respectively, by a representative household. The function is positive, continuously twice differentiable and strictly quasi-concave together with

$$u^h{}_{x^h} > 0, \quad u^h{}_{y^h} > 0.$$

Given the constant returns to scale for technology, a number of perfectly competitive firms can be considered as a single aggregate firm with the production possibility function

$$f(X, Y, Z, i) = 0,$$

where X and Y denote the production of the resource and the consumption goods, respectively. Since emission Z and the resource X are joint products, for simplicity, a one-one emission relation ($\rho = 1$) is assumed. Hence, a general production possibility function may be reduced into

$$F(Y, X, i) = 0$$

which is positive, continuously twice differentiable and define a strictly convex production possibility set. The marginal production cost of X, in terms of the quantity of Y sacrificed, is

$$-\frac{dY}{dX} = \frac{F_X}{F_Y} = MRT > 0$$

and

$$\frac{d}{dX}\left(-\frac{dY}{dX}\right) = \frac{d}{dX}\left(\frac{F_X}{F_Y}\right) = \frac{dMRT}{dX} > 0.$$

i is parameter representing the upgrade in basic facilities (e.g., railway). An increase in i enhances the productive capacity and shifts the marginal production cost down, which gives

$$\frac{dMRT}{di} = \frac{d}{di}\left(\frac{F_X}{F_Y}\right) < 0.$$

Social cost arising from the exploitation of X, is denoted by

$$D = D(X, a) \text{ and } D_X > 0,\ D_{XX} \geq 0,$$

which could be measured in terms of numeraire goods used to clean up the environmental damage (Adar and Griffin, 1976). The marginal external cost is assumed to be constant or increasing in the quantity of the pollutant and subject to a shift parameter a representing the upgrade in the pollution treatment facilities (e.g., water treatment plant). An increasing in a shifts the marginal social cost down, which gives

$$D_{Xa} < 0.$$

For a strictly convex production possibility set, its frontier point, on which the revenue line tangent to, is associated with the profit maximizing and cost minimization production plan. Given the technological constraint represented by the production possibility set, the representative aggregate firm's maximization problem is then

$$\max \quad Y + (p^* - t)X$$

subject to

$$F(Y, X, i) = 0,$$

where t is the levy imposed on polluter intended to control the social cost. The implementation of the levy is the responsibilities of the local governments. Since Z is an ingredient output, the pollution charge on pollution Z is equivalent to a pollution charge on X. The first-order condition for this maximization problem is

$$p^* - t = \frac{F_X}{F_Y} \ldots (1).$$

That is, the optimal pollution charge is such that the producer price $p = p^* - t$ is equated to the marginal production cost F_X / F_Y.

The firm is responsive to such environmental issues. The first-order condition yields a supply function of X

$$X = X(p, i).$$

differentiating (1) gives

$$dp = \frac{d}{dX}\left(\frac{F_X}{F_Y}\right)dX + \frac{d}{di}\left(\frac{F_X}{F_Y}\right)di.$$

It has been assumed that

$$\frac{d}{dX}\left(\frac{F_X}{F_Y}\right) > 0 \text{ and } \frac{d}{di}\left(\frac{F_X}{F_Y}\right) < 0,$$

such that

$$\frac{dX}{dp} > 0 \text{ and } \frac{dX}{di} > 0.$$

Thus, the supply curve of X is positive sloped, and an increase in i increases the output of X.

Social utility maximization problem can be shown as

$$\max \quad \sum_{h=1}^{H} u^h = u^h\left(x^h, y^h\right)$$

subject to

$$p^* X - \sum_{h=1}^{H} p^* x^h - D(X,a) = \sum_{h}^{H} y^h - Y$$

$$\left(\sum_{h=1}^{H} \left(y^h + p^* x^h\right) = Y + p^* X - S, \text{where } S = D \right)$$

$$F(Y, X, i) = 0$$

The first constraint states the balance of trade. The quantity of the numeraire goods importable Y is the exportable supply of X, exclusive of external cost (The consumption equals the production, exclusive of ecological destruction compensation. The environmental impact is addressed through remedial measures and S is the numeraire goods used to clean up the environmental damage).

This condition is applicable in current Tibet declaring the fully autonomy in its economic development. Rich resources make Tibet be of great advantages of being a resource supplying region. Law on Regional Ethnic Autonomy protects that the Tibetans to be the first to administer and utilize its natural resources (White Paper on Tibet, 2004, p. 7). The Tibetans trade the surplus natural resources (X) with the rest of the country for various consumption goods and services (Y) to improve their standard of living. Meanwhile, with support from the central government of China, the government of the Tibet is carrying out measures to restore the ecological quality of Tibet to a relatively steady or even better status. The second constraint represents the production possibility frontier. The Lagrangian for this maximization problem may be written as

$$L = \sum_{h=1}^{H} u^h\left(x^h, y^h\right) + \lambda\left(\sum_{h=1}^{H} \left(y^h + p^* x^h\right) - \left(Y + p^* X - D(X,a)\right) \right) + \mu\left(F(Y, X, i)\right).$$

Partially differentiate the Lagrangian with respect to unknown variables and put them to zero. The first-order conditions are therefore:

$$u^h_{x^h} + \lambda p^* = 0 \quad \forall h$$

$$u^h_{y^h} + \lambda = 0 \quad \forall h$$

$$-\lambda\left(p^* - D_X\right) + \mu F_X = 0$$

$$-\lambda + \mu F_Y = 0$$

The optimum condition gives

$$\frac{u^h_{x^h}}{u^h_{y^h}} = MRS = p^*,$$

and

$$p^* - D_X = \frac{F_X}{F_Y} \ldots (2),$$

which implies

$$MRS - D_X = MRT.$$

That is, the marginal rate of transformation is the difference between the marginal rate of substitution (MRS is the amount of consumption goods that the household must be given to compensate him for the marginal reduction in his consumption of the resource.) and marginal social cost, when the optimum is achieved from social point of view.

Comparing equation (1) and (2) gives the optimal pollution charge

$$t = D_X\left(X\left(p^* - t, i\right), a\right) \ldots (3).$$

This is the first-best pollution levy: the optimal levy should equal the marginal social cost. Differentiating equation (3) yields

$$dt = D_{XX} X_p dp^* - D_{XX} X_p dt + D_{XX} X_i di + D_{Xa} da,$$

which gives

$$\frac{dt}{dp^*}=\frac{D_{XX}X_p}{1+D_{XX}X_p}$$

$$\frac{dt}{di}=\frac{D_{XX}X_i}{1+D_{XX}X_p}$$

$$\frac{dt}{da}=\frac{D_{Xa}}{1+D_{XX}X_p}$$

If $D_{XX}=0$, then t is not affected by changes in the exogenous price ($dt/dp^*=0$) and the upgrade in infrastructure ($dt/di=0$). In this case, a constant pollution levy achieves socially optimal. On the other hand, if $D_{XX}>0$ then t increases with the exogenous prices ($dt/dp^*>0$). An upgrade in basic facilities increases the output ($dX/di>0$ derived from differentiating formula 1) and increases the levy ($dt/di>0$). Finally, an upgrade in pollution treatment facilities decreases the levy ($dt/da<0$) whether D_{XX} is positive or zero.

Figure 1 illustrates how t responds to an increase in p^*. At any X, marginal social cost D_X is represented by the interval between p^* and p^*-t. Increasing marginal social cost ($D_{XX}>0$) is the cause of this interval increasing with X. The marginal production cost of X (F_X/F_Y) is increasing. In the absence of social cost, the private producers equate p^{*1} and F_X/F_Y, producing X^0. Due to the social cost, the social optimal output occurs at X^1. This output can be achieved by a pollution levy t^1. An increase in the exogenous price from p^{*1} to p^{*2} results a new production at X^2. Consequently, the levy rises to t^2.

Figure 2 illustrates how t responds to an increase in i. It is assumed that an increase in i decreases the marginal production cost ($d(F_X/F_Y)/di<0$). An upgrade in basic facilities causes the marginal production cost curve shifted downward from $F_X/F_Y{}^1$ to $F_X/F_Y{}^2$, and therefore, an increased social optimal output from X^1 to X^2 ($dX/di>0$). The pollution levy rises from t^1 to t^2 ($dt/di>0$).

Figure 3 illustrates how t responds to an increase in a. It is assumed that an increasing in a decrease the marginal social cost ($D_{Xa}<0$).

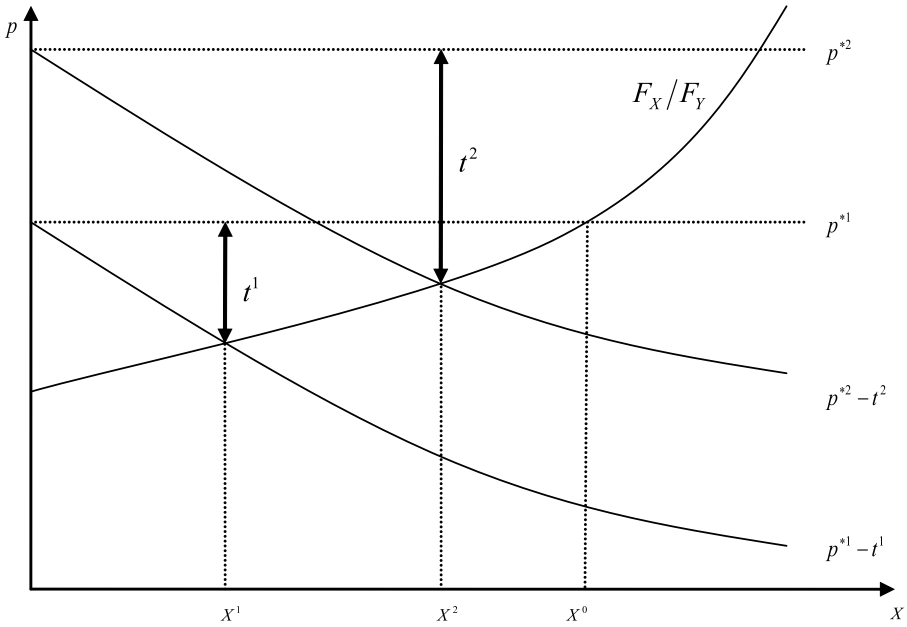

Figure 1 Pollution levy and the exogenous price

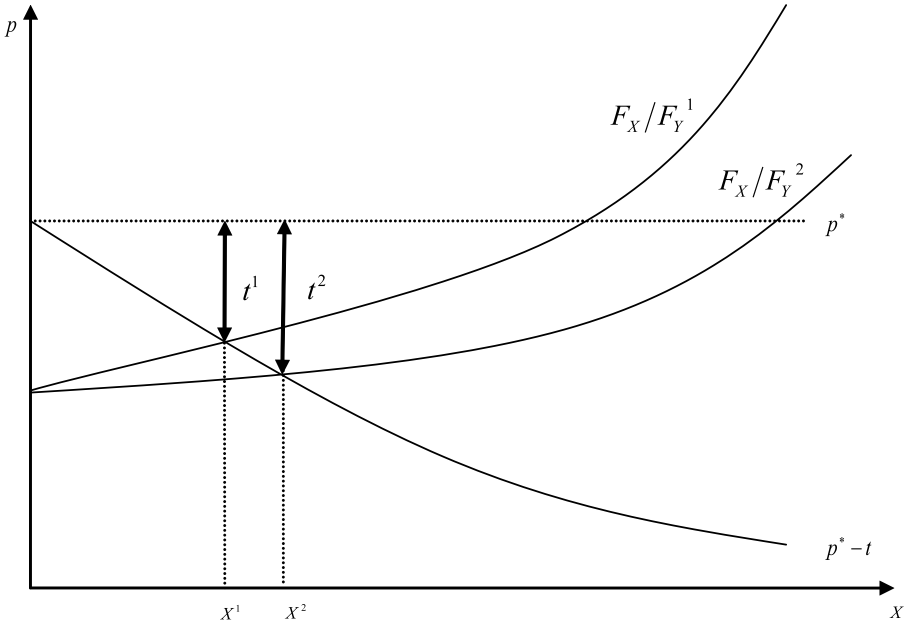

Figure 2 Pollution levy and the marginal production cost (increase in a)

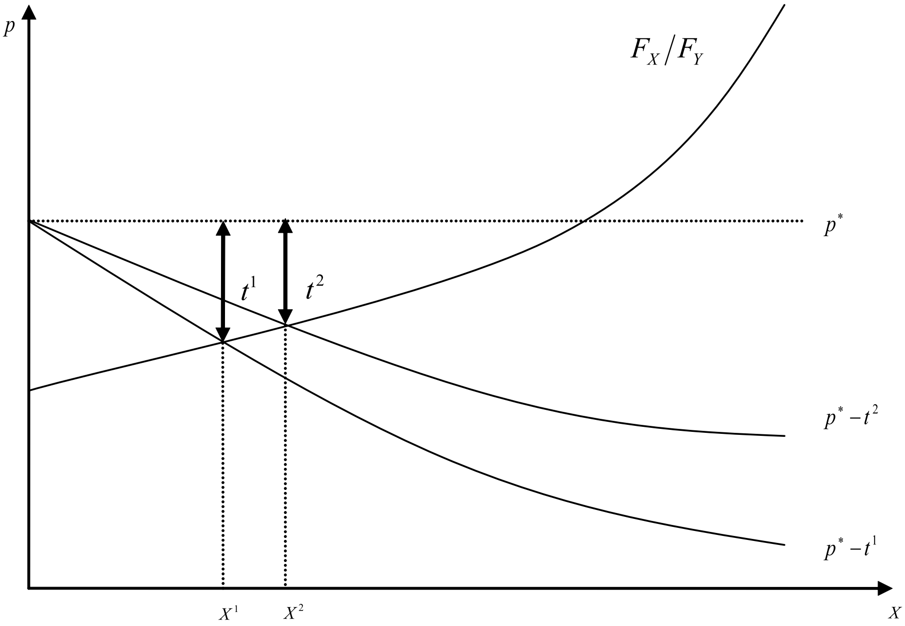

Figure 3 Pollution levy and the marginal social cost (increase in i)

An upgrade in the pollution treatment facilities narrows the interval representing the marginal social cost of the resource exploitation from between p^* and $p^* - t^1$ to between p^* and $p^* - t^2$. The social optimal output increase from X^1 to X^2 and pollution levy decreases from t^1 to t^2 ($dt/da < 0$).

3. Policy implications

3.1 Current pollution levy system

Originally the pollution levy applied only to the emissions in excess of certain maximum allowable levels. The system calculated a pollution levy only on those pollutants that did not comply with regulatory effluent standards. Then, among these calculated levies, the firm paid the levy only on the pollutant which violated the standard by most. Thus most emissions were not subject to the levy. In 1991 the system was changed so that the levy is applied on all pollutant discharges, not just those above a certain level. Current pollution levy system is the most extensive one in the world in terms of the number of pollutants covered. The 2003 levy system covers 65 water pollutants, 44 air pollutants and other pollutant in the media of solid wastes and noise (中国国家环境保护总局, 2003, p.98).

Article 10 of Chapter 2 of the EPL indeed states "the competent department of environmental protection administration under the State Council shall, in accordance with the national standards for environment quality and the country's economic and technological conditions, establish the national standards for the discharge of pollutants". The State Environmental Protection Administration (SEPA) established the national levy rates for the discharge of pollutants (中国国家环境保护总局, 2003, p.101).

In the case of industrial waste water, the SEPA has established the uniform rate at 0.7 yuan per pollutant equivalent, which is enforced all over the country including Tibet (西藏自治区人民政府, 2003). Accordingly, the levy in Tibet can be calculated (the amount of pollutant equivalent in actual wastewater discharge multiplied by 0.7 yuan). The formula to calculate the levy is

$$\text{levy} = \sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{K}\right)_{\text{m}} \times 0.7\ \text{yuan/pollutant equivalent.}$$

K is 0, when the pollution levy is settled, K is 2, when the pollution equivalent violate the nation standard and K is 1 for all else situations. Small letter m is the maximum 3 calculated in the parenthesis, which implies the levy is calculated according to the 3 pollutants which violated the environment by most. The amount of pollutant equivalent is calculated by

$$\text{pollutant equivalent (61 normal pollutents)} = \frac{\text{quantity of pollutant discharged (kg)}}{\text{pollutant equivalent value (kg)}},$$

$$\text{pollutant equivalent (pH value, coliform groupe bacteria index and residual chlorine)} = \frac{\text{discharge of sewage (ton)}}{\text{pollutant equivalent value (ton)}},$$

$$\text{pollutant equivalent (chromaticity)} = \frac{\text{discharge of sewage (ton)} \times \text{times in excess of the color standard (times)}}{\text{pollutant equivalent value (ton} \cdot \text{times)}}.$$

Variables of numerators are observable. The pollutant equivalent values of denominators for 61 normal pollutants, pH value, coliform group bacteria, residual chlorine and chromaticity are uniformly determined by SEPA (中国国家环境保护总局, 2003, pp. 103-105).

Different levy rates have been established for air pollutants. SEPA set 44 types of air pollutants and their pollutant equivalent values (中国国家环境保护总局, 2003, pp. 106-107). Formula to calculate the levy is

$$\text{levy} = \sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{correspondent rate/pollutant equivalent}\right)_{\text{m}},$$

where

$$\text{pollutant equivalent (44 types of air pollutants)} = \frac{\text{quantity of pollutant discharged (kg)}}{\text{pollutant equivalent value (kg)}}.$$

3.2 Improvement of pollution levy system

The WCDS brought out three exogenous variables in the presence of social cost: national price, infrastructures and pollution treatment facilities, which has not been considered in the current implementation of the pollution levy. The ecosystem in Tibet is extremely fragile, and the ability to resist disturbance and regenerate is weak. Once the ecosystem is damaged, it is hard to restore it for a long period of time (White Paper on Tibet's Ecology, Environment and the Dalai Lama, 2003, p. 8). Consider the fragileness of Tibet environment, it is safe to assume $D_{XX} > 0$. Then, in the light of the theoretical finding, there is considerable room for improving the effectiveness of the current levy.

Zhang et al, (1997) developed a formula to estimate levy for industrial waste water that fully consider the variations of region and basin, water quality requirements and inflation. Adjustment coefficients taking into account the changes of non-pollutant factors were inserted into the formula to match the circumstance in specific regions and cities. The calculation method is as follows

$$\text{levy} = \text{K1} \times \text{K2} \times \text{K3} \times \text{K4}^{\text{n - 1994}} \times \text{T} \times \text{W}$$

where

T=levy rate (0.7 yuan per pollutant equivalent)

W=pollutant equivalent

K1=regional adjustment coefficient (1 to 1.5)

K2=basin adjustment coefficient (1 to 1.5)

K3=water quality function zone adjustment coefficient (1 to 1.5)

K4=inflation adjustment coefficient (n is the time order).

The formula combines the scale of pollutant (W) with three location coefficients (K1, K2 and K3) and an inflation coefficient (K4) that provide a valid method to reflect, in the levy, the level of pollution, the sensitivity of the local environment and the variation in price index.

This study will extend this useful conception, the above research on water pollution levy provided, into levy calculation and develop the conception a little more fully. In general, the reform of Tibet pollution levy system may involve integrating the non-polluting indexes into the levy to approach marginal social costs and modifying the pollution levy on a basis to reflect the distinctive natural and geographical figures of the region. Following Zhang et al, notations for K1, K2 and K3, this study recommends the formulas below to calculate the levy. They are

$$\text{levy} = \text{K1} \times \text{K2} \times \text{K3} \times \left(\frac{p_t}{p_{t-1}} \times \frac{I_t}{I_{t-1}} \times \frac{A_{t-1}}{A_t} \right) \times \sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{K} \right)_{\text{m}} \times 0.7 \text{ yuan/pollutant equivalent}$$

and

$$\text{levy} = \text{K1} \times \left(\frac{p_t}{p_{t-1}} \times \frac{I_t}{I_{t-1}} \times \frac{A_{t-1}}{A_t} \right) \times \sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{correspondent rate/pollutant equivalent} \right)_{\text{m}},$$

respectively, for the water and air pollutants of mining in Tibet.

p_t= the present term (measured in month or season) price of a resource,

p_{t-1}= the correspondent preceding term price of the same resource,

I_t= the stock of basic facilities in the present term,

I_{t-1}= the stock of basic facilities in the preceding term,

A_t= the stock of pollution treatment facilities in the present term, and

A_{t-1}= the stock of pollution treatment facilities in the preceding term.

These variables are determined depending on various complex market and political factors.

The advantage of employing such formulas to calculate the levy is its small policy cost. Proportional expressed coefficient p_t / p_{t-1} guarantees the levy increases with the national price. In practice, policy regulators may observe fluctuations in the price of the resource and compute the ratio. The proposed approach also provides regulators a reasonable approximation that to what extent the production cost and pollution reduction will occur, which depend very much on the utilization of the basic facilities and the pollutant treatment facilities installed in Tibet. Coefficient $I_t / I_{t-1} (A_{t-1} / A_t)$ guarantees the levy increase (decrease) with the upgrade in basic facilities (pollution treatment facilities). The value of each proportional expressed coefficient may vary significantly as the demand for raw mineral resources soaring and the implementation of the WCDS.

Tibet is the water tower of Asia, the importance of which is now gradually appreciated by the people living downstream in China and the rest of Asia. Hence, Zhang et al, (1997) location coefficients K1, K2 and K3 still hold in the water pollution levy formula of this study. In order to reflect the effect of the environment of the Tibet plateau on the steady of Asian monsoon and jet-streams (high altitude wind) that below over the plateau (李, 2006), a regional adjustment coefficient K1 is inserted in the air pollution levy formula, which adjusts the levy to a higher level.

The legal system also guarantees the effective implementation of such regional pollution levy system. Article 16 of Chapter 3 of the EPL states “the local people’s governments at various levels shall be responsible for the environmental quality of areas under their jurisdiction and shall take measures to improve the quality of the environment”. Article 10 of Chapter 2 states “the people’s governments of provinces, autonomous regions and municipalities directly under the Central Government may establish their local standards for the discharge of pollutants for items not specified in the national standards; with regard to items already specified in the national standards, they may set local standards which are more stringent than the national standards”. Environmental Protection Bureaus (EPB) has been created at all levels of local governments. Once the proposals have been implemented, Tibet EPB is thus in large part the responsibilities for the implementation of such levy system.

3.3 An ad valorem levy approach

An ad valorem levy which involves higher information cost may be introduced to achieve more precisely approach to the marginal social cost. The exogenous market price p^* for raw material is easy to verify and it is difficult to quantify the optimal pollution levy $t = p^* - p$ when producer price p is a non-linear function. Baumol and Oates (1971) developed levy and standard approaches, a pragmatic technique that aimed at efficiency without optimality. Adar and Griffin (1976) compared the relative efficiency of pollution levy, standard, and the auctioning of pollution rights when the marginal damage function or marginal control function is subject to uncertainty. Using a linear pollution levy, Choi and Johnson (1992) provided a linear approximation of the optimum.

In practice, a linear ad valorem levy can be written as a constant specific tax and an ad valorem tax

$$T = s + \alpha p^*.$$

Consequently, the producer price is

$$p^s = p^* - T = (1 - \alpha) p^* - s.$$

For policy maker, the regulatory problem is to estimate s and α.

Applying Zhang et al., (1997) formula to estimate the pollution levy in Tibet (coefficient K1, K2, K3 and K4 for water pollutants and K1 and K4 for air pollutants), requires levy $\bar{t}$ is a specific pollution levy. Then, the producer price curve $p = p^* - t$ under the specific pollution levy lies below the 45 degree line and is parallel to it (Figure 4).

As is shown in Figure 5, there exists a

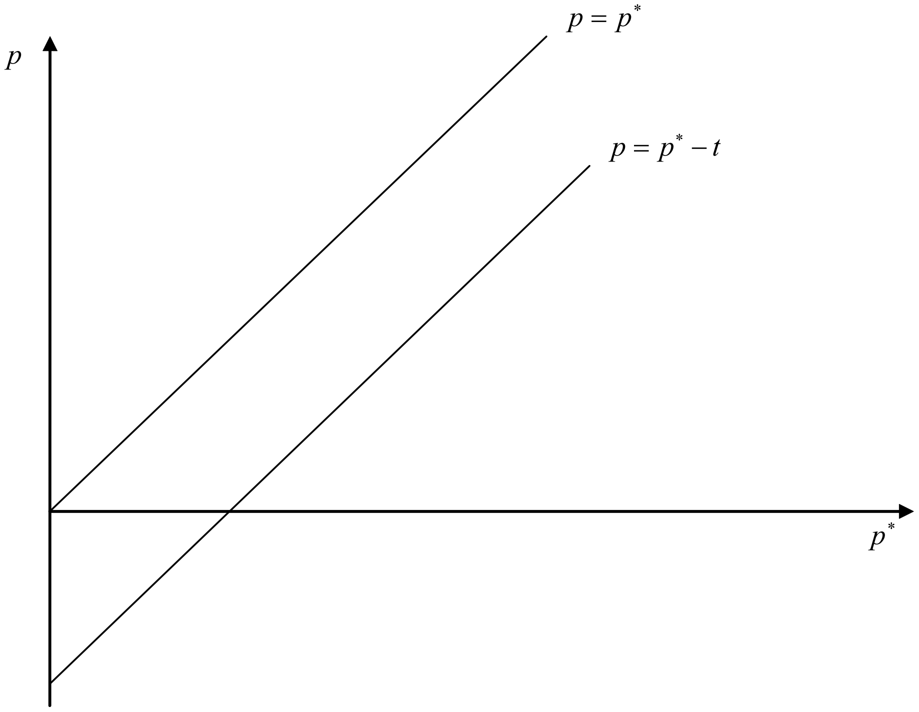

Figure 4 Producer price under a specific pollution levy

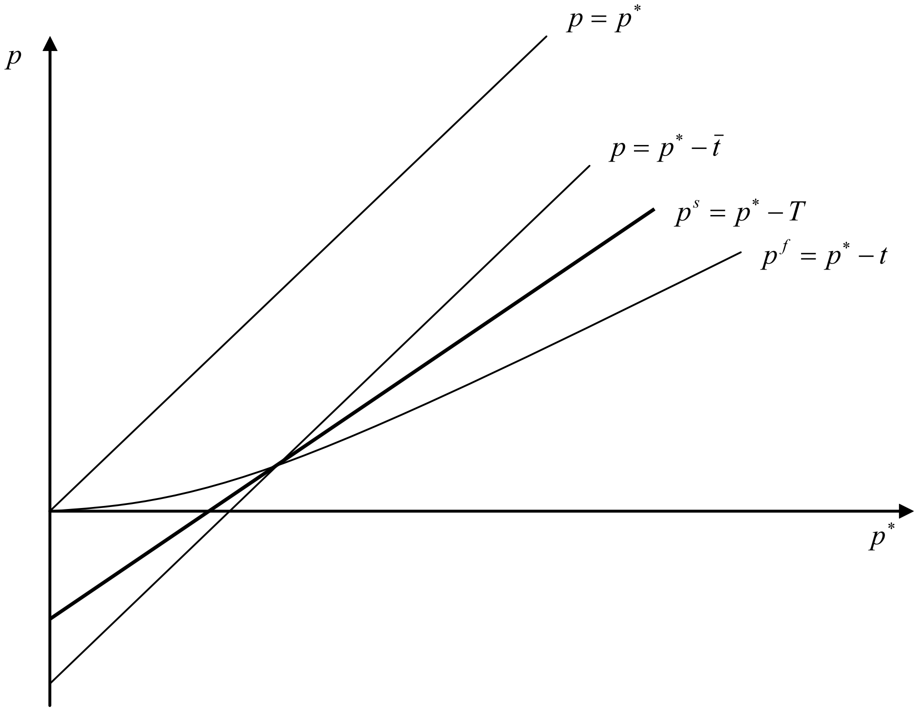

Figure 5 An ad valorem pollution levy dominants a specific pollution levy

straight line, $p^s = (1-\alpha)p^* - s$ passing through the intersection of p and the optimal producer price p^f. In order to let this line be flatter than p, that is, closer to p^f, it requires a positive coefficient $0 < \alpha < 1$ and a specific effluent tax s, which is less than the specific pollution charge $\bar{t}$. Hence, when the national price is the only non-pollutant factor of variation, a linear ad valorem levy may be employed to achieve more precisely approach to marginal social cost. The result leads to an immediate policy implication that the formulas to calculate the levy for water and air pollutants are, respectively,

$$\text{levy} = \text{K1} \times \text{K2} \times \text{K3} \times \sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{K}\right)_{\text{m}} \times 0.7\ \text{yuan/pollutant equivalent} + \alpha p_t$$

and

$$\text{levy} = \text{K1} \times \sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{correspondent rate/pollutant equivalent}\right)_{\text{m}} + \alpha p_t.$$

In addition to national price, other non-pollutant factors may shift the marginal social cost towards a new level. Below is a set of diagrams seeks to obtain the dominant policies to cope with the shifted marginal social cost. In the closed up Figure 6, the optimal producer price p^{f1} is shifted downward to p^{f2} due to the increased marginal social cost. An increase in the specific levy s (positive coefficient α) shifts (turns) line p^{s1} downward to p^{s3}(p^{s2}) passing through the new intersection of line p and p^{f2}. Line p^{s2} is flatter that p^{s3} everywhere, that is, closer to the optimal producer price p^{f2}.

In the closed up Figure 7, the optimal producer price p^{f1} is shifted upward to p^{f2} due to the decreased marginal social cost. An cut in the specific levy s (positive coefficient α) shifts (turns) line p^{s1} upward to p^{s2} (p^{s3}) passing through the new intersection of line p and p^{f2}. Line p^{s2} is flatter that p^{s3} everywhere, that is, closer to the optimal producer price p^{f2}.

Table 1 summarizes the dominant policies

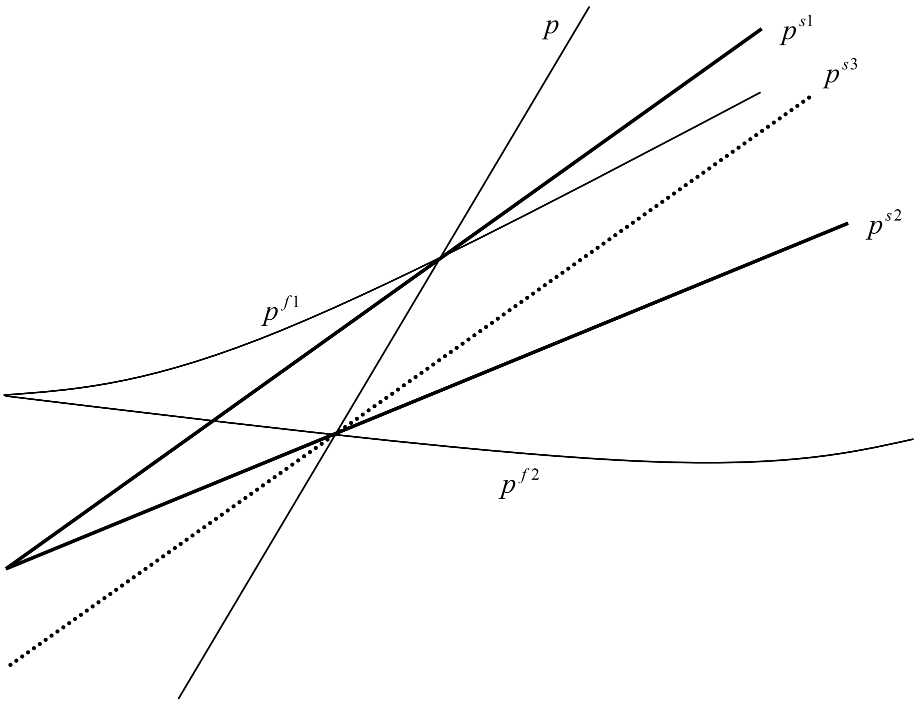

Figure 6 Increasing α dominants increasing s under increased marginal social cost

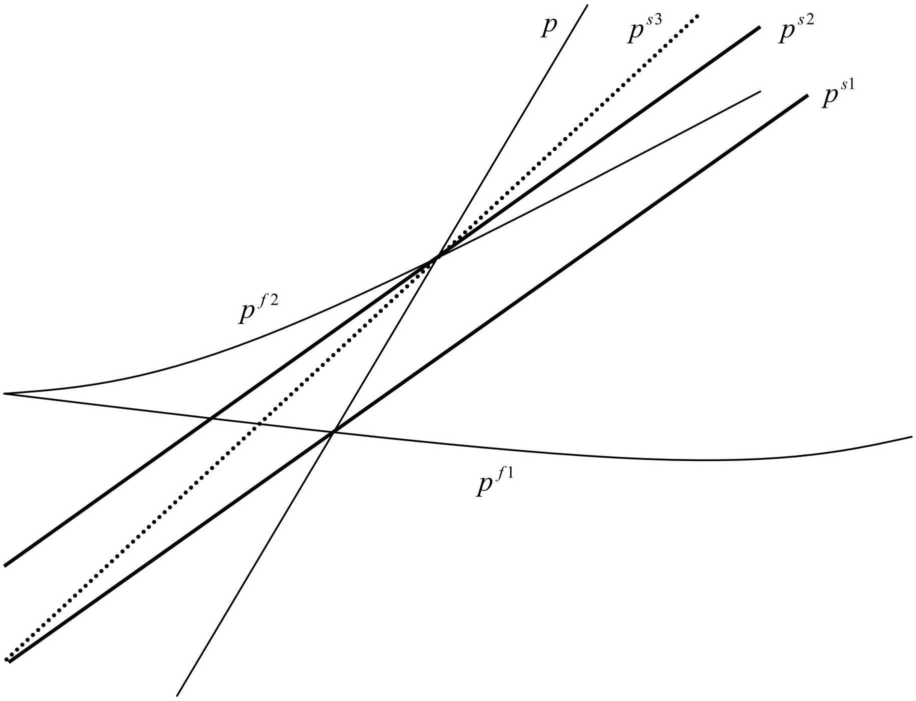

Figure 7 Decreasing s dominants decreasing α under decreased marginal social cost

Table 1 Dominant policy options for an ad valorem pollution levy

	Increased marginal social cost (Figure 6)	Decreased marginal social cost (Figure 7)
Specific levy s	To be increased	To be decreased (dominant policy)
Positive coefficient α	To be increased (dominant policy)	To be decreased

presented in the diagrams. Policy makers may modify either s or α to approximately approach to the shifted marginal social cost. As is shown in Figure 6, increase the positive coefficient α yield a closer approximation of the increased marginal social cost than increase the specific levy s. Figure 7 shows that decrease the specific levy s yield a closer approximation of the decreased marginal social cost than decrease the positive coefficient α. There is considerable validity to extend the result into the levy calculation to make it perform better when marginal external cost is subject to the shifts arising from the other non-pollutant factors in addition to price. The recommended formulas to calculate the levy are, for water pollutants

$$\text{levy} = \text{K1} \times \text{K2} \times \text{K3} \times \sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{K}\right)_{\text{m}} \times \text{0.7 yuan/pollutant equivalent} + \left(\frac{I_t}{I_{t-1}} \times \frac{A_{t-1}}{A_t} \right) \times \alpha p_t$$

for air pollutants

$$\text{levy} = \text{K1} \times \sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{correspondent rate/pollutant equivalent}\right)_{\text{m}} + \left(\frac{I_t}{I_{t-1}} \times \frac{A_{t-1}}{A_t} \right) \times \alpha p_t$$

when

$$\frac{I_t}{I_{t-1}} \times \frac{A_{t-1}}{A_t} > 1.$$

and for water pollutants

$$\text{levy} = \text{K1} \times \text{K2} \times \text{K3} \times \left(\frac{I_t}{I_{t-1}} \times \frac{A_{t-1}}{A_t} \right) \times$$

$$\sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{K} \right)_{\text{m}} \times 0.7 \text{ yuan/pollutant equivalent} + \alpha p_t$$

for air pollutants

$$\text{levy} = \text{K1} \times \left(\frac{I_t}{I_{t-1}} \times \frac{A_{t-1}}{A_t} \right) \times$$

$$\sum_{\text{m}} \left(\text{pollutant equivalent} \times \text{correspondent rate/pollutant equivalent} \right)_{\text{m}} + \alpha p_t$$

when

$$\frac{I_t}{I_{t-1}} \times \frac{A_{t-1}}{A_t} < 1.$$

The specific levy s is the first part of each formula and policy makers in Tibet may be more confidence in policy design when unobservable coefficient α is precisely estimated. Although the regulatory problem involves the estimation of unobservable coefficients, the burden of the information to implement such pollution levy may bring potential gains through more precise approach to the marginal social cost.

4. Conclusion

When China's other regions are under the threat of pollution, Tibet, which holds the country's biggest amount of fresh water, is still a place with minimum pollution. However, a healthy environment is not sufficient in itself to alleviate the poverty. The world's highest railway extends Tibet to the outside market. Exploration of natural resources along the Qinghai-Tibet railway is significant to the railway's efficient use, regional economic development and meeting China's resources demand. On the other hand, the exploitation of natural resources generates social cost into Tibet environment.

On trans-regional spheres, this study analyzed the social cost associated with mining to inform policy makers to establish an effective pollution levy system. Given the fragileness of Tibet environment, it is reasonable to state the marginal damage increases in the quantity of pollutants. Then, non-pollution factors become variables in the presence of social cost. An increase in national market price increases the levy. An upgrade in infrastructure (pollution treatment facilities) increases (decreases) the levy.

The result has important policy implications. For water and air pollutants incur to the resources exploitation, a set of formulas are prospected to estimate the levy. Proportional expressed adjustment coefficients taking into account the variations of non-pollutant factors have been inserted into the formulas to match the circumstance in Tibet. The advantage of employing such pollution levy system is its small policy cost. In practice, policy regulators may observe fluctuations in each non-pollutant variable and compute the ratio. The value of each proportional expressed coefficient may vary significantly as the demand for raw material resources soaring and the implementation of the WCDS, and therefore vary the levy.

Furthermore, since exogenous market price for raw material is easy to verify, an ad valorem approach, which entails higher information cost is introduced to achieve more precisely approach to marginal social cost. Dominant policies are also prospected, when marginal social cost is subject to the shifts arising from other non-pollutant factors in addition to price. For policy maker, the regulatory problem involves the estimation of unobservable coefficients. The burden of the information to implement such pollution levy may bring potential gains through more precise approach to the marginal social cost.

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